1 Biology

1.1 Species and Family Overview

This first section provides details on how to identify the different species described in this book.

Below is a brief description of the present-day families. The classification of species (and hence their scientific names) changes as we learn more about how closely they are related to other species. Most texts quickly become out of date as the taxonomists and systematists learn more about the relationship between and within different species. For an in-depth description with identification keys, the reader is directed to specialist publications such as Ernst and Barbour's *Turtles of the World* and Ferri's *Turtles and Tortoises*, which are good texts that provide more detailed information (see Figures 1.4.1 and 1.4.2 for scute nomenclature).

Cheloniidae The six species of hard-shelled Sea turtles.

Carettochelyidae This family has only one living species, the Pig-nosed turtle. The forelimbs are modified as flippers. It has a pig-like snout, and a smooth carapace from which scutes are absent.

Dermochelyidae There is only one species in this family, the Leatherback sea turtle.

Trionychidae There are approximately 22 species in this family of semi-aquatic turtles, which comprises the soft-shell turtles. The shell is reduced and incomplete. The carapace is leathery and pliable, particularly at the sides. They have elongated, soft, snorkel-like nostrils. Their necks are disproportionately long in comparison to their bodies.

Kinosternidae Approximately 22 species are recognised in this family, which consists of the Mud turtles and the Musk turtles. Usually, one or two plastral hinges present.

Essentials of Tortoise Medicine and Surgery, First Edition. John Chitty and Aidan Raftery.

They have less than 12 plastron scutes. Some degree of toe webbing is present. They are small- to medium-sized semi-aquatic turtles.

Dermatemydidae There is one species, the Central American River turtle, which is almost totally aquatic. Inframarginal scutes are present.

Platysternidae There is one species, the Big-headed turtle. The head is so big that it cannot be withdrawn into the shell. Inframarginal scutes are present.

Chelydridae There are four living species, the Alligator snapping turtle and three species of Snapping turtles. These are very aggressive turtles, with powerful jaws. Inframarginal scutes are present. There is a long tail. The rough carapace is keeled and strongly serrated posteriorly. The plastron is reduced and hingeless.

Testudinidae There are approximately 50 living species. This is the most common family presented for veterinary treatment in Europe. The hind limbs are columnar. Inframarginal scutes are absent. There are two phalangeal bones in the digits of the hind feet. There is no webbing of the toes. The genus *Kinixys* are the only tortoises with a hinge of the carapace. If a plastron hinge is present between the femoral and abdominal scutes, then the tortoise is in the genus *Testudo*, with the exception of *Testudo horsfieldi* (Horsfield's tortoise), which is recognisable by the horny claw on the end of its tail and by having only four claws on each forefoot. If the hinge is between the humeral and pectoral scutes, then this is *Pyxis arachnoides*, the Malagasy Spider tortoise. If the plastron is rigid with a very flat and flexible carapace, then this is *Malacochersus*, the Pancake tortoise. These are tortoises with paired gulars that project anteriorly beyond the carapace rim, especially in males and in the genus *Gopherus*, the Gopher tortoises. Where the supracaudal scute is undivided, then the tortoise is of the genus *Geochelone*.

Guide to identification to the genera of the Testudinidae

Kinixys This genus contains six species. They are the only tortoises with a movable hinge in the carapace. Three species are seen relatively commonly. In *Kinixys homeana* (Home's hinge-back tortoise), the posterior portion of the carapace is strongly inverted from the level of the anterior end of the fifth vertebral scute. The inversion of the carapace starts at the middle of the fifth vertebral scute in *K. erosa* (the Serrated hinge-back tortoise) and *K. belliana* (Bell's hinge-back tortoise). The posterior rim of the carapace of *K. erosa* is strongly serrated, while the same area of *K. belliana* is not serrated, or only weakly serrated.

Acinixys This genus contains one species: *Acinixys planicauda*, the Madagascar Flat-shelled spider tortoise. The tail is flattened and its dorsal surface is covered with enlarged scales. There is a slight medial ridge on the maxillae. The plastron is hingeless. The gulars are paired, thickened and extend slightly beyond the rim of the carapace.

Pyxis This genus contains one species: *Pyxis arachnoides*, the Malagasy Spider tortoise. The plastron has a hinge between the humeral and pectoral scutes.

Chersina This genus contains one species: *Chersina angulate*, the South African Bowsprit tortoise. The plastron is hingeless. There is a single gular scute that projects anteriorly. The anal scute is large in contrast to the other species with a single projecting gular scute, *Geochelone yniphora*.

Homopus This genus contains five small species of tortoise. The plastron is hingeless. The gulars are paired, and broader than they are long.

Psammobates This genus contains three species. These colourfully patterned small tortoises are known as South African Star tortoises. The plastron is hingeless. The gulars are paired and broader than they are long. The carapace is domed, with ascending sides.

Manouria This genus contains two species: *Manouria emys*, the Asian Brown tortoise, with two recognised subspecies; and *Manouria impressa*, the Impressed tortoise. The plastron is hingeless. The forefoot has five claws. The supracaudal scute is subdivided into two. Large black blotches occur on the marginal.

Indotestudo This genus contains two species of medium-sized tortoises: *Indotestudo elongata*, the Elongated tortoise; and *Indotestudo forsteni*, the Travancore tortoise. The plastron is hingeless. The forefoot has five claws. The supracaudal scute is subdivided into two. There is a long terminal tail scale. They are a light cream–yellow colour, with brownish blotches on the carapace and to a lesser extent on the plastron. They have a short trachea, which is significant when intubating.

Geochelone This is the largest genus, containing 21 species. All species within this genus are relatively large when adult. The plastron is hingeless. This genus includes the commonly kept species *Geochelone sulcata* (the African Spurred tortoise), *G. pardalis* (the Leopard tortoise) and *G. carbonaria* (the Red-footed tortoise).

Testudo This genus contains six or seven species, depending on whether *Testudo weissingeri* is classified as a species or a subspecies. They all have club-like fore and hind feet. All also have five claws on the forefeet, except for *Testudo horsfieldi*, which has four. The gular scutes are paired, but not projecting beyond the carapacial rim.

- The hinge in the plastron is between the femoral and the abdominal scutes, with the exception of *Testudo horsfieldi*, which lacks the movable hinge.
- *Testudo hermanni* can be distinguished from the others of the genus by having a horny spur on the end of its tail: there are no enlarged tubercles on the thigh and the supracaudal scute is usually divided.
- *Testudo graeca* has an enlarged tubercle on the thigh, the supracaudal scute is undivided and there is no horny terminal tip to the tail. It is important to distinguish the Tunisian tortoise, *Furculachelys nabeulensis*, from *Testudo graeca*. Until recently, it was classified as a subspecies of *T. graeca* due to similarities.

Figure 1.1.1 *Testudo marginata*. Notice the greatly flared supercaudal and posterior marginal.

Unlike *T. graeca*, this species does not hibernate. The key differences from *T. graeca* are as follows: the supracaudal scute is curled; they are very small, with adults rarely exceeding 16.5 cm carapace length; and the carapace is light yellow in colour, with strong black markings in the scute centres. They are brightly coloured: the scutes have a black edging and a black spot in the centre, and there is a distinct yellow spot on the head, between the eyes.

- *Testudo iberia* has a flatter and broader carapace than *T. graeca*. They grow much larger and are often paler in colour, although darker populations do occur. The first vertebral scute is more angular in *T. iberia* compared to the more rounded shape in *T. graeca*.
- In *Testudo marginata*, the supercaudal and the posterior marginal are greatly flared (see Figure 1.1.1). There are four or five longitudinal rows of enlarged scales on the anterior surface of the foreleg.
- *Testudo kleinmanni* is the smallest species (see Figure 1.1.2). There is no tubercle on the thigh, only the supracaudal scute is flared and there are usually only three longitudinal rows of enlarged scales on the anterior surface of the foreleg.
- *Testudo weissingeri* was originally considered a dwarf population of *T. marginata*. They have similar identifying features; however, they are much smaller. They can usually be distinguished from *T. marginata* by the carapace coloration, which is dull brown or blackish, with greyish-yellow or horn-collared patches flecked with grey. This compares with a more contrasting pattern of a pale yellow on black seen with *T. marginata*.

Gopherus This genus contains four species of tortoises from North America. Their forelimbs are flattened as an adaptation for burrowing. The carapace is

Figure 1.1.2 *Testudo kleinmanni* is the smallest in the *Testudo* genus.

Figure 1.1.3 *Gopherus polyphemus*. Note the lack of a cervical indentation.

flattened and lacks a cervical indentation (see Figure 1.1.3). The plastron is hingeless. They all have paired gular scutes that project anteriorly, especially in males. This genus includes the Gopher tortoise (*Gopherus polyphemus*), which is often kept in North America.

Malacochersus This genus contains one species: *Malacocherus tornieri*, the African Pancake tortoise. The carapace is flattened and flexible. The juvenile carapacial fenestra are retained into adulthood. This allows this species to take refuge in narrow cracks. The plastron is hingeless.

Emydidae These are mainly found in North America. They can be divided between the Box turtles of the genus *Terrapene*, where the anterior and posterior portions of the plastron close completely, and Pond turtles, known in some parts of the world as terrapins, where there is no hinge. The family also includes *Emys orbicularis*, the European Pond turtle, and *Emydoidea blandingii*, Blanding's turtle, where a hinge is present, although in the adult it does not close completely. Inframarginal scutes are absent. There are three or more phalangeal bones in digits 2 and 3 of the hind feet. There is usually some degree of webbing. *Deirochelys reticularia*, the chicken turtle, is recognisable because of its long neck: if measured from shoulder to snout, its length is approximately equal to that of the plastron. *Trachemys scripta elegans*, the Red-eared slider, is instantly identified by the typical reddish marks on the side of its head, often accompanied by a red spot on top of its head. This species is captive farmed in large numbers for the pet trade.

Geoemydidae This is a diverse family of turtles, with about 70 species. It includes the Asian Pond and River turtles, and the Asian Box turtles and other turtles.

Pelomedusidae and Chelidae These are the side-necked turtles. These semi-aquatic animals are carnivorous. Only the Chelidae have a nuchal scute.

Further reading

Bonin, F., Devaux, B. & Dupré, A. (2006) *Turtles of the World*. A&C Black, London.

Ernst, C.H. & Barbour, R.W. (1989) *Turtles of the World*. Smithsonian Institution Press, Washington, DC.

Ferri, V. (2002) *Turtles and Tortoises*. Firefly Books, Willowdale, Ontario.

1.2 Natural History

As with all exotic species kept in captivity, a good knowledge of the natural history of these animals is essential in order to understand their various needs in captivity, especially relating to husbandry, diet, reproduction and behaviour.

The following provides a brief guide to the main species that are kept as pets. As described in Chapter 1.1 and in the sources of information for this section (see below), there is some controversy in the classification and identification of these species. Therefore, some generalisations have been made within these descriptions.

Testudo graeca (Mediterranean Spur-thighed Tortoise)

There is much controversy over the classification of these tortoises. Fortunately, there is much in common between their basic diet and climate.

Distribution

T. g. graeca, found from northern Morocco to Libya, in southern Spain and in Sardinia/Sicily.

T. g. terrestris, found in southern Turkey, Syria, Lebanon, Jordan and from Israel to northern Egypt/Libya.

T. g. zarudnyi, found in Iran, Afghanistan and Pakistan.

Habitat

Arid areas from sea level to > 3000 m altitude.

Hibernation

High-altitude populations hibernate.

Smaller subspecies found at sea level tend not to – they are more likely to aestivate in hot weather. Because of the difficulties in identifying subspecies, smaller thinner individuals should not be hibernated.

Diet

Vegetative detritus: a wide variety of fibrous plants, especially their flowers.

Reproductive data

- Season: April to June (usually May/June).
- Eggs per clutch: 2–7.

- Laying site: 10 cm deep cavity.
- Incubation time: 3–4 months, although some reports suggest that eggs of *T. g. zarudnyi* may overwinter in the cooler parts of the range.

Furculachelys naebulensis (Tunisian Tortoise)

Distribution
Tunisia/western Libya.

Habitat
Sea level – arid areas.

Hibernation
Does not hibernate.

Diet
Vegetative detritus: a wide variety of fibrous plants, especially their flowers.

Reproductive data
- Season: April to June (usually May/June).
- Eggs per clutch: 2–7.
- Laying site: 10 cm deep cavity.
- Incubation time: 3–4 months.

Testudo ibera (Greek Spur-thighed Tortoise)

Distribution
North-east Greece, parts of the Balkans, the northern Aegean islands, and from parts of Turkey to Iran/Iraq.

Habitat
Arid areas from sea level to > 3000 m altitude.

Hibernation
From November to February.

Diet
Vegetative detritus: a wide variety of fibrous plants, especially their flowers.
However, more omnivorous than *T. graeca*. Some individuals may consume molluscs and insects.

Reproductive data
- Season: April to June.
- Eggs per clutch: 6–7.
- Laying site: 10 cm deep cavity.
- Incubation time: 3–4 months.

T. hermanni (Hermann's Tortoise)

Distribution

The western subspecies (*T. h. hermanni*) is found in north-eastern Spain, south-east France, western/southern Italy and Majorca, Minorca, Sardinia, Sicily and Corsica.

The eastern subspecies (*T. h. boettgeri*) is found in eastern Italy, the Balkans, Greece and western Turkey.

Habitat

Semi-open areas around forested regions.

Hibernation

Variable period between October and March.

Diet

More than 90% herbivorous – similar to *T. graeca*, but appears to favour legumes and clovers over grasses.

Will opportunistically eat worms, snails and carrion.

Reproductive data

- Season: mid-May to July.
- Eggs per clutch: 2–12.
- Laying site: 7–10 cm deep cavity.
- Incubation time: 90 days.

T. horsfieldi (Horsfield's Tortoise, aka Russian/Steppe/ Afghan Tortoise)

Distribution

South-eastern Russia, Iran, Afghanistan and Pakistan.

Habitat

Dry steppe up to 2500 m altitude.

Usually found near water.

Hibernation

Yes – can be > 6 months, as adapted to very hot summers and very cold winters.

Digs long, deep burrows to protect from weather extremes.

May aestivate in summer.

Diet

Vegetation – grasses, flowers and leaves.

Reproductive data

- Season: mating mid-March to end of April; females lay eggs in May/June.
- Eggs per clutch: 1–5 eggs per nest, in 1–4 nests.
- Laying site: excavated burrows.
- Incubation time: 100 days.

T. marginata (Marginated Tortoise)

Distribution
Greece, Sardinia.

Habitat
Dry scrub and woodland.
Hillsides.

Hibernation
Yes.

Diet
Herbivorous – grasses, flowers and some fruits.

Reproductive data
- Season: April to June; eggs laid June/July.
- Eggs per clutch: 3–11.
- Laying site: 10 cm deep excavations.
- Incubation time: 2–4 months, depending on soil temperature.

T. kleinmanni (Kleinmann's or Egyptian Tortoise)

Distribution
Coastal Libya and Egypt; Israel.

Habitat
Desert and semi-desert scrub.

Hibernation
No – will aestivate in hot weather.

Diet
Mainly herbivorous – especially saltwort and sea lavender.
May take some insects and carrion.

Reproductive data
- Season: mating in autumn, with eggs laid in early spring.
- Eggs per clutch: 1 – very large; rarely up to 4.
- Laying site: buried in sand.
- Incubation time: 4–5 months.

Geochelone sulcata (Sulcata or African Spurred Tortoise)

Distribution
Sub-Saharan Africa – isolated populations from Mauritania (west) to Ethiopia/Eritrea (east).

Habitat
Arid acacia forest and woodland.

Hibernation
No – will spend dry season in burrows.

Diet
Any vegetation.
During the dry season may also take carrion and organic detritus.
Will store dry vegetation in burrows for feeding during the dry season.

Reproductive data
- Season: nest November to May.
- Eggs per clutch: 2–4 nestings per female, with up to 19 eggs per nest.
- Laying site: up to 40 cm deep nests.
- Incubation time: 120–210 days, depending on the timing of the rainy season.

G. pardalis (Leopard Tortoise)

See Figure 1.2.1.

Distribution
Eastern sub-Saharan Africa and southern Africa.

Habitat
Dry savannah, semi-desert, finbos.

Hibernation
No, but will hide in tunnels/burrows during cold periods at high altitude.

Diet
Mainly herbivorous – almost anything consumed.
Will also take carrion and excrement of other animals.

Figure 1.2.1 The Leopard tortoise. Pyramiding may be seen in wild specimens, but is normally a consequence of abnormal growth in captivity.

Reproductive data
- Season: warm months – either May to June or October to November, depending on latitude.
- Eggs per clutch: up to 30 eggs each year, in up to six nests.
- Laying site: 10–30 cm deep in dry/stony soil.
- Incubation time: approximately 100 days, but up to 380 days reported.

G. carbonaria (Red-foot Tortoise)

Distribution
Northern South America.

Habitat
Open areas and dry forest.

Hibernation
No – aestivates in summer.

Diet
Mainly herbivorous – especially fallen fruit.
Will take carrion and invertebrates.

Reproductive data
- Season: June to September.
- Eggs per clutch: 2–15.
- Laying site: against trees, beside pathways in leaf litter or in soil.
- Incubation time: 3–6 months, depending on humidity and sunlight exposure.

G. denticulata (Yellow-foot Tortoise)

Distribution
Northern South America and Amazonian lowlands.

Habitat
Humid forest – lives under leaves.

Hibernation
No.

Diet
Insects, larvae and fallen fruit.

Reproductive data
- Season: throughout the year with several clutches per female – generally in drier seasons.
- Eggs per clutch: 1–12.
- Laying site: eggs laid on the ground.
- Incubation time: 4–5 months.

G. elegans (Indian Star Tortoise)

Distribution
Peninsular India and Sri Lanka.

Habitat
Tropical deciduous forest and dry savannah, but does need a supply of water.

Hibernation
No.

Diet
Herbivorous – especially fruits, vegetables and succulent leaves.
Will eat carrion and insects.

Reproductive data
- Season: mates in rainy season; nests May to June and October.
- Eggs per clutch: 3–6 per clutch; up to four clutches per season.
- Laying site: 10–15 cm deep.
- Incubation time: approximately 120 days.

Gopherus agassizii (Desert Tortoise)

Distribution
Sonoran and Mojave Deserts in southern United States (USA)/northern Mexico.

Habitat
Desert oases, canyon bottoms and rocky hillsides.
Needs sandy/gravelly soil for digging burrows.

Hibernation
No, but aestivates for part of the summer.

Diet
Largely herbivorous – especially grasses and cacti.
Will also eat carrion.

Reproductive data
- Season: nests May to July.
- Eggs per clutch: approximately 6.
- Laying site: 20 cm deep burrow in sandy soils.
- Incubation time: 3 months.

Gopherus polyphemus (Gopher Tortoise)

Distribution
Atlantic and Gulf Coastal plains of the USA.

Habitat
Well-drained sandy soil between grassland and woodland.

Hibernation
No.

Diet
Grasses, leaves, hard fruits, bones and insects.

Reproductive data
- Season: March to July.
- Eggs per clutch: approximately 7.
- Laying site: often buried close to parent's burrow – approximately 15 cm deep.
- Incubation time: 80–110 days.

Trachemys scripta elegans **(Red-eared Slider, or Terrapin)**

T. scripta scripta may also be seen in captivity – its natural history is very similar to that of *T. s. elegans*.

Distribution
South-eastern USA, but has been introduced to many other areas, including the United Kingdom (UK).

Habitat
Calm water with a muddy bottom, abundant vegetation and basking sites.

Hibernation
Aestivates in summer.
Is capable of hibernation in cooler parts of its range.

Diet
Entirely carnivorous when young: older animals also take vegetation.

Reproductive data
- Season: courtship in spring/summer, in water; nests on land April to July.
- Eggs per clutch: 2–23.
- Laying site: buried in soil/sand.
- Incubation time: 60–80 days.

Terrapene **spp. (North American Box Turtles)**

T. carolina (Common box turtle) and *T. ornata* (Ornate box turtle) are most commonly seen in captivity.

Distribution
USA – the most common species (*T. carolina*) ranges over the entire eastern USA from southern Canada to northern Mexico.

Habitat
Mainly wetter woodland close to watercourses.
In dry southern areas, adapts by restricting activity to rainy months and by hiding in mud or under leaves.

Can tolerate salty water, and all species can tolerate periods of weeks to months away from water.

Hibernation
Yes – in northern parts of range.

Diet
Young mainly carnivorous (invertebrates, carrion), becoming more herbivorous as they get older.
All eat mushrooms.

Cuora spp. (Asian Box Turtles)

The Amboina box turtle (*C. amboinensis*) is most commonly seen in captivity.

Distribution
South-East Asia.

Habitat
Swamps, small watercourses and rice paddies.
Can also be found on land.

Hibernation
No.

Diet
Most are omnivorous – the proportion of meat and vegetation varies from species to species.
Young are more carnivorous than older animals.

Trionychidae (Soft-shell Turtles)

There are a large number of Soft-shelled turtle species – the exact species is often unknown by the owner and the animal's provenance is not always clear.

Where possible, the animal should be identified and its husbandry based on natural history.

Distribution
Asia, southern USA, equatorial Africa, Australasia.

Habitat
Typical muddy-bottomed streams, rivers, swamps and lakes.

Hibernation
No.

Diet
Carnivorous, although some species are omnivorous.

Chelidae (Side-necked/Snake-necked Turtles)

There are a large number of Side-necked turtle species – the exact species is often unknown by the owner and the animal's provenance is not always clear.

Where possible, the animal should be identified and its husbandry based on natural history; however, all species are tropical/subtropical and have similar habitats, meaning that generalisations may be made in terms of husbandry and diet.

Distribution
Asia, southern USA, equatorial Africa, Australasia.

Habitat
Generally prefer shallow ponds and slow-moving water.

Hibernation
No.

Diet
Carnivorous, although some species are omnivorous.

Carettochelys insculpta (Fly River Turtle, or Pig-nosed Turtle)

These are often sold to keep in fish tanks, but this is not recommended as they are piscivorous. However, a typical warm-water tank set-up may be appropriate.

Distribution
Southern Papua New Guinea and some rivers of northern Australia.

Habitat
Calm rivers and lagoon – may also tolerate salt water and enter the sea.

Hibernation
No.

Diet
Snails, fish crustaceans and fallen fruit.

Reproductive data
- Season: nests July to November, in the dry season.
- Eggs per clutch: 15–30.
- Laying site: shallow nests in mud/sand banks – excavated when females emerge from water at night.
- Incubation time: stimulated to emerge by rising water.

Chelus fimbriatus (Mata Mata)

Distribution
Northern South America.

Habitat
Edges of wetlands and slow rivers.

Hibernation
No.

Diet
Carnivorous – especially fish and amphibia.

Reproductive data

- Season: October to December.
- Eggs per clutch: 12–30.
- Laying site: eroding river cliffs.
- Incubation time: 80 days on average, but varies according to humidity and sun exposure.

1.3 Sex Determination and Incubation of Eggs

Determination of sex is not always straightforward in Chelonia. As described below, the vast majority have temperature/environmental-determined sex rather than genetic-determined sex as in mammals and birds.

This means that DNA cannot be used to determine sex (as is done in avian medicine).

In the clinical setting, imaging may be used to visualise the internal gonads: ultrasonography (Chapter 7.2) can be used to visualise mature follicles on the ovary, although coelioscopy (Chapter 7.3) is most useful in visualising and identifying both mature and immature gonads of either sex. However, this technique will require some form of anaesthesia/sedation and is invasive.

Therefore, it is most useful to be able to physically identify sex from the anatomical characteristics of each species. As well as requiring good knowledge of the species involved (see Chapter 1.1), this also requires a lot of experience in determining often subtle differences. Clinicians interested in improving their knowledge are well advised to spend time with experienced breeders of these species and to examine a lot of individuals. This is especially important when trying to sex juveniles, where the differences between the sexes may be minimal. In these cases, it is important that owners are not misled by a 'guess' and uncertainty over the sex of the animal is conveyed to the owner.

Table 1.3.1 gives a brief guide to the different physical characteristics of the sexes in those species covered by this book. Some care is required when using plastron or carapace shape in captive-bred specimens, where abnormal growth and nutritional secondary hyperparathyroidism may affect the shell shape such that the sex-related shape is obliterated.

Environmental sex determination

As discussed above, in most species (the notable exception being the Soft-shelled turtles, Trionychidae), incubation temperature determines sex. It is, of course, vital to know which temperatures produce which sex offspring if a mixed sex population is to be produced and maintained.

Table 1.3.1 Anatomical sex differences in chelonian species

Species		Male	Female
Testudo graeca	Mediterranean Spur-thighed tortoise	• Longer, thicker tail; vent opening beyond the rim of the carapace • Concavity of plastron • Wider anal scutes	• Shorter tail; vent opening at, or cranial to, rim of carapace • Flat plastron; some flattening of caudal carapace dorsal to tail • Narrower anal scutes
T. ibera	Greek Spur-thighed tortoise   **Figures 1.3.1 and 1.3.2** Spur-thighed tortoises: male (1) and female (2)	• Longer, thicker tail; vent opening beyond the rim of the carapace • Concavity of plastron • Wider anal scutes	• Shorter tail; vent opening at, or cranial to, rim of carapace • Flat plastron; some flattening of caudal carapace dorsal to tail • Narrower anal scutes
Furculachelys naebulensis	Tunisian tortoise	Longer, thicker tail; vent opening beyond the rim of the carapace	Shorter tail, vent opening at, or cranial to, rim of carapace

(Continued)

Table 1.3.1 (Cont'd)

Species		Male	Female
T. hermanni	Hermann's tortoise  **Figure 1.3.3** Western subspecies – male	Long tail, with long keratinised tip **NB** These differences are very marked in the smaller western subspecies (*T. h. hermannii*). In the larger eastern subspecies (*T. h. boettgeri*), the differences are more subtle. As in the Spur-thighed group (see above), there may be differences in the anal scute.	Tail shorter, with shorter keratinised tip
T. horsfieldi	Horsfield's tortoise (aka Russian/ Steppe/Afghan tortoise)	Longer tail, with vent close to the tip	Shorter tail; vent more cranial
T. marginata	Marginated tortoise	Longer tail, with vent close to the tip	Shorter tail; vent more cranial
T. kleinmanni	Kleinmann's or Egyptian tortoise	Longer tail, with vent close to the tip	Shorter tail; vent more cranial
Geochelone sulcata	Sulcata, or African Spurred tortoise	• Anal scute curvature wide and shallow  **Figure 1.3.5** Note the pointed tail and the shape of the anal scute	• Anal scute curvature deeper and narrower • Plastron flat

		• Plastron concave  **Figure 1.3.6** Note the concave plastron	
G. pardalis	Leopard tortoise	• Anal scute curvature wide and shallow • Plastron concave • Hindlimb spurs larger in males	• Anal scute curvature deeper and narrower • Plastron flat
G. carbonaria	Red-foot tortoise  **Figure 1.3.4** Male right: female left	• Longer tail • Concave plastron • Anal scute curvature wide and shallow • 'Body shape' thinner, with an obvious 'waist' when viewed from above	• Shorter tail • Flat plastron • Anal scute curvature deeper and narrower • Much wider body shape
G. denticulata	Yellow-foot tortoise	• Concave plastron • Carapace expanded over hind legs • Longer tail • Low, flattened, elongated profile	• Flat plastron • Domed carapace • Shorter tail

(*Continued*)

Table 1.3.1 (Cont'd)

Species		Male	Female
G. elegans	Indian Star tortoise	Longer, thicker tail	• Larger than male • Broader profile
Gopherus agassizii	Desert tortoise	• Larger than female • Longer tail • Concave plastron • Large glands under chin • Longer claws	• Shorter tail • Flat plastron • Chin glands and claws smaller
Gopherus polyphemus	Gopher tortoise	• Concave plastron • Large glands under chin	• Flat plastron • Chin glands much smaller
Trachemys scripta elegans	Red-eared slider (or terrapin)	• Smaller than females • Longer tail • Vent caudal to rim of carapace • Some subspecies have long curved claws on forelegs	• Shorter tail • Vent cranial to/level with rim of carapace
Terrapene spp.	North American Box turtles	In general, males have longer, thicker tails than the females, with the vent caudal to the carapace rim; some species differences exist in terms of claw length and plastron shape; in the adult common/Carolina Box turtle, the iris is red	In general, shorter tail with vent cranial to/level with the carapace rim; in the adult common/Carolina Box turtle, the iris is yellow–brown
Cuora spp.	Asian Box turtles	• Long, thick tail • Concave plastron	• Short, stubby tail • Flat plastron
Trionychidae	Soft-shell turtles	Longer tail, with vent near the tip	Shorter tail, with more cranial vent
Chelidae	Side-necked/Snake-necked turtles	Longer tail than female; species differences, with some having a concave plastron compared with the female; in some species, the male is flatter than the female	Shorter tail; in some species, the female is more domed than the male
Carettochelys insculpta	Fly river turtle (or Pig-nosed turtle)	• Long, pointed tail • Swelling at base of tail • When tail extended, cloacal opening beyond margin of caudal scutes	• Long, pointed tail • No swelling at base of tail • When tail extended, opening just cranial to margin of caudal scutes
Chelus fimbriatus	Mata mata	• Longer, thicker tail • Concave plastron	• Shorter tail • Flat plastron

Table 1.3.2 Temperature-determined sex in Chelonia

Testudo graeca *Testudo hermanni*	Males, 26–29.5 °C Mixed, 30–31 °C Females, 31.5–34 °C
Graptemys spp. (Map turtles) *Trachemys scripta* (Red-eared slider) *Chrysemys picta* (Painted turtle)	Males, 28 °C Mixed, 29 °C Females, 30 °C
Chelydra serpentina (Snapping turtle)	Females at 20 °C and > 30 °C Males, 22–28 °C

Table 1.3.2 gives these data for those species where this has been determined (see Deeming 2004).

Incubation in captivity

In the UK, it is rare that chelonian eggs can be incubated 'naturally', with the possible exception of the temperate freshwater turtles (e.g. the Red-eared slider) in the south of the country. They must therefore be collected and artificially incubated.

Veterinary surgeons are regularly contacted about what to do with eggs that are produced 'unexpectedly'. In these cases, it is essential to check whether the eggs are fertile. In other words, are a male and female both present? This may require sexing of 'parents' (see above).

It is also important to check that the owners actually want to incubate the eggs and possibly hatch offspring. In these cases, they will also need to be advised regarding preparation of vivaria for young Chelonia, and on the legal requirements should they wish to sell or exchange the offspring.

Reptile eggs lack chalazae and are therefore very susceptible to damage when moved. They should always be handled carefully and never turned. Once collected (as soon as possible after laying), they should not be moved again other than for occasional assessment of viability.

Assessment of viability is relatively straightforward in these thin-walled white eggs. Eggs can be candled (as for birds, using a bright light in a dark room) from relatively early in incubation. Because of the difficulty in handling, this is usually only performed near the end of incubation when eggs have not hatched as expected.

The incubation period for most species is not precise and the incubation time will be shorter at higher incubation temperatures. It will also vary slightly according to the surrounding humidity/substrate water content. As an approximation, *Testudo* spp. eggs hatch in approximately 75 days, while softer-shelled freshwater turtle eggs hatch in approximately 55–65 days.

The incubation temperature is influenced by the sex ratio required (see earlier). In general, most breeders try to incubate around the sex determination cut-off temperature unless a very skewed population is required. They have a fairly wide range of tolerance – typically 24–32 °C – though temperatures should be adapted to each species' natural requirements.

Reptile eggs do best in a 'wet' environment. They should be covered in vermiculite or a half sand/soil mixture. They do not need a deep layer of substrate, but should be just covered. In natural conditions, the fluid that accompanies laying will be sufficient to keep the egg moist during incubation. However, when eggs are collected, this is lost. Therefore, the substrate should be slightly dampened after covering. Where the water potential can be assessed, it should be maintained at –150 to –200 kPa. Alternatively, a commercial incubator may be used, with eggs placed on a substrate of damp vermiculite. Water bowls are placed in the incubator such that the humidity is maintained between 50 and 80%.

NB Care must be taken with hygiene if doing this, with a safe disinfectant added to the water, coupled with regular changes, in order to avoid bacterial infections.

For more information, see Deeming (2004).

Reference

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World Chelonian Trust – http://www.chelonia.org/sexdetermination.htm

1.4 Physiology/Anatomy

The Chelonia are a subgroup within reptiles.

There are 13 families of living Chelonia, with more than 287 species.

The Chelonia are divided into two groups:

- The Cryptodira, which includes the most commonly seen species. These can draw their heads and necks straight back into their shell.
- The Pleurodira, which bring their heads and necks in to the side (the side-necked turtles).

The shell

The most distinctive feature of chelonians is their shell. The upper part of the shell is called the carapace and the lower part is called the plastron. They are joined together on both sides by the bridge. The shell is made of about 60 bones fused together. This includes the ribs and most of the vertebrae. The outside of the shell is covered by keratinous scales called scutes: for scute nomenclature, see Figures 1.4.1 and 1.4.2. The margins of the scutes do not line up with the sutures of the underlying dermal bones. Soft-shelled turtles do not have scutes. Instead, their shell is covered with leathery skin. There are numerous variations in the shell shape and the size and number of scutes present. In addition, many species have hinges in their shells. Hinges in the plastron are most common, but a few species have carapacial hinges.

- The pectoral girdle is inside the ribs; that is, inside the shell. The scapula is L-shaped; it meets the humerous and the coracoid bone at its angle to form the shoulder joint.
- The pelvic girdle is composed of the ilium, ischium and pelvic bones, which meet to form the acetabulum. The ilium is attached dorsally to the sacral ribs in the Cryptodira. In the Pleurodira, the pubic and ischium are attached ventrally, giving a more robust framework.
- The limbs are relatively short but contain the same bony arrangement found in the commonly presented mammals; however, there are many modifications

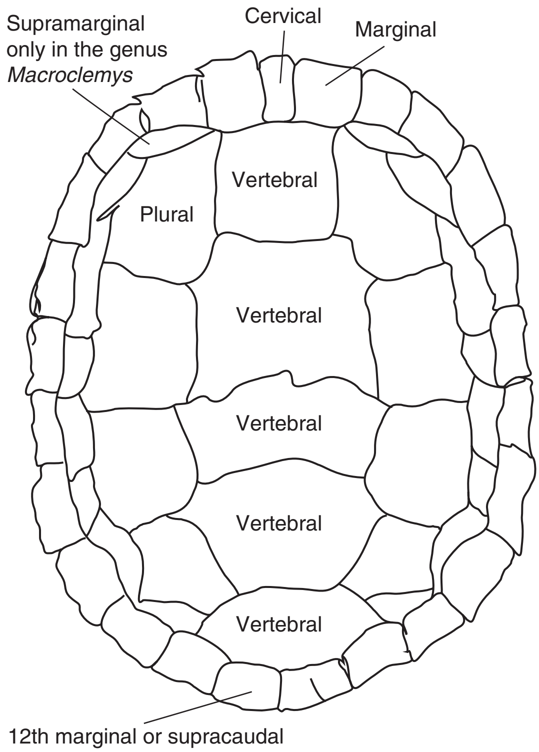

Figure 1.4.1 Carapacial scute nomenclature.

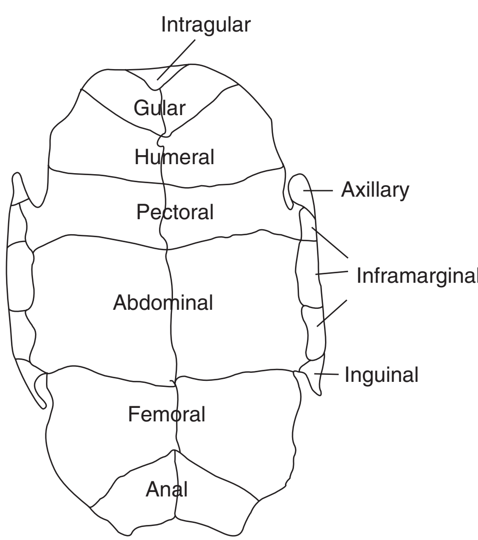

Figure 1.4.2 Plastron scute nomenclature.

of shape. Aquatic species have flattened webbed feet for more efficient swimming.
- The skull is relatively small in most species to allow retraction into the shell. The retractor muscles of the head are well developed to strongly pull the head to safety inside the shell.

Respiratory system

- Air enters the body through the external nares into the nasal cavity.
- The glottis is located on the floor of the mouth just behind the tongue.
- The glottis is positioned at the choana when the mouth is closed.
- The glottis has two arytenoid and one cricoid cartilages.
- The epiglottis is missing.
- The trachea has complete tracheal rings.
- Tracheal length varies among the species, but in some species it divides into primary bronchi cranially.
- The paired lungs are positioned dorsally against the carapace.
- The lungs are sac-like structures, partitioned into chambers.
- There is no diaphragm. The pleuroperitoneal membrane separating the lungs from the rest of the coelomic cavity is relatively thin and non-muscular.
- Muscle movements of the limbs and the pectoral and pelvic girdles create the negative pressure to draw air into the lungs.
- Chelonians are unable to cough effectively and clear secretions from the lower respiratory tract. This makes recovery from pneumonia more problematic.

See Figure 1.4.3.

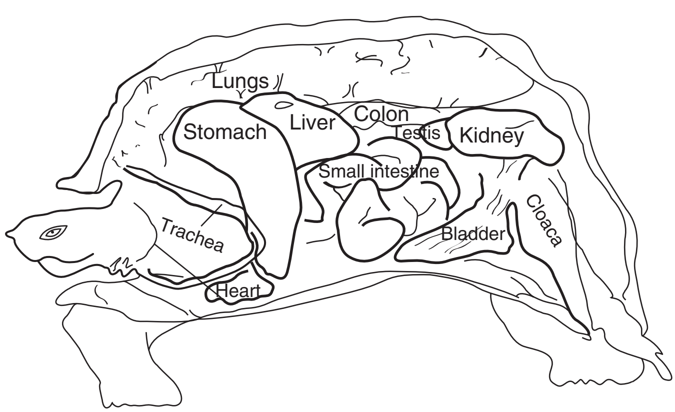

Figure 1.4.3 Anatomy: lateral section.

Cardiovascular system

- The heart is on the midline, just behind the pectoral girdle.
- The pericardial sac contains a small volume of clear to yellow pericardial fluid.
- The heart is three-chambered, but functionally the pulmonary and systemic circulation are separate.
- There is a renal portal system, but pharmacological trials reveal that the choice of drug injection site does not affect pharmacokinetics.

Digestive system

Oral cavity

- Chelonia do not have teeth; they have a horny beak (the rhamphothecae) attached over the jaw bones.
- The lower beak should fit just inside the upper beak, producing a shearing mechanism.
- They will also attempt to rip off pieces of food by retracting their strong neck muscles. In captivity, they learn to put a foot on the food before pulling back.
- Medial to the beak there is a horizontal crushing surface.
- Mucus membranes are moist and have a pink colour.
- They have thick fleshy tongues that have numerous taste buds. Their tongues cannot protrude from the mouth.

Gastrointestinal section

- The stomach is positioned on the left side, just before the middle of the plastron.
- The small intestines are relatively short and positioned in the caudal half of the coelomic cavity.
- As in most other vertebrates, the small intestines are suspended by the mesentery.
- The small intestine empties into the caecum, which is not well developed.
- The colon can be divided into three parts, the ascending, transverse and descending colon.
- Pebbles and other foreign material often remain in the dilated portion of the transverse colon for prolonged periods. This is on the left side of the coelomic cavity.
- Herbivores have modified the colon into sacculations for microbial fermentation.
- Nematodes of the order Oxyurida are commonly found and are believed to assist in the breakdown of the ingesta.
- The colon terminates in the cloaca.
- The gastrointestinal transit time varies with diet, with the animal in its Preferred Optimal Temperature Zone (POTZ). In herbivorous species, it can vary from 3 to 30 days.

See Figure 1.4.4.

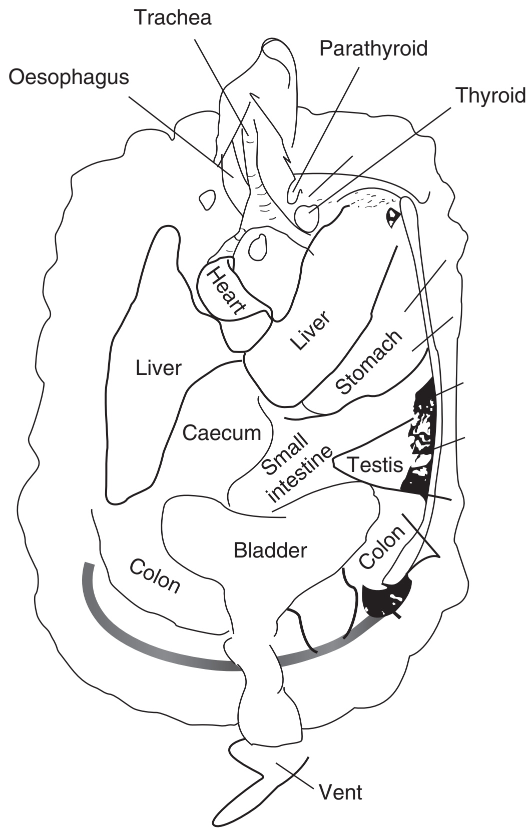

Figure 1.4.4 Anatomy: dorsoventral section.

Liver

- This large organ is positioned directly posterior to the heart.
- It is divided into two lobes with a gall bladder on the right side.
- The liver's main functions are glucose supply, fat metabolism, fat storage, protein metabolism, blood filtration, bile production and exocrine hormone production.
- Large amounts of fat may be stored in the liver in preparation for reproduction and hibernation.

Cloaca

- This is a short large bore tube, which terminates through the vent.
- Theoretically, the cloaca is divided into three sections, the coprodeum, urodeum and proctodeum.
- The digestive tract empties into the coprodeum, the proximal portion.

- The genital and urinary tracts terminate in the urodeum, the middle portion.
- These divisions are not very obvious in the animal.

Urinary system

- The paired kidneys lie in the caudal coelom, just behind the acetabulum.
- The ureters are short and empty into the neck of the urinary bladder.
- The urinary bladder is large. It is a bilobed structure with thin membranous walls.
- The urethra enters the urodeum ventrally.
- Antiperistalsis can move urine anteriorly into the coprodeum and colon, where water can be resorbed.

Reproductive system – male

- The paired, oval-shaped testis are positioned in the caudal coelomic cavity. They are closely associated with the kidneys.
- The male has a single phallus, which protrudes from the ventral wall of the proctodeum.
- The phallus is not involved in urination. There is a groove – the seminal groove – in the phallus, which can be seen when it is engorged. This transports the semen.

Reproductive system – female

- There are right and left ovaries, lying just cranial to the kidneys.
- Ovary size varies, depending on the stage of follicular activity.
- Sperm can be stored by the female for several years.
- The oviduct can be divided into five areas, the ostium, aglandular portion, magnum, shell gland and vagina.
- During ovulation, the ostium moves over the ovary to collect the ovulating follicules.
- Follicules pass straight through the aglandular portion to the magnum area, where albumen is added.
- They then move to the shell gland area, where the shell is added.
- Eggs are stored in the vaginal area until deposition.

Eyes

- Chelonia have functional eyelids and palpebral fissures as found in mammals.
- The lower eyelid is larger and the most mobile, as in birds.
- There is a well-developed nictitating membrane.
- A nasolacrimal duct has not been identified in chelonians.
- Hardarian and lacrimal glands are found in the bony orbit, in similar positions as found in mammals.

- The iris is under voluntary control.
- The retina is avascular, nourished by choroidal vessels.
- The conus papillaris is a vascular structure that projects into the vitreous and is believed to also nourish the retina. It is similar to the pectin oculi of birds.
- Chelonians have both cones and rods, allowing significant colour vision.
- Several species have been shown to have UV vision. Most species of chelonians are believed to have UV vision.

Smell

- The sense of smell is well developed in chelonians.
- Smell is believed to be an important stimulus to normal feeding.

Ears

- Chelonia lack an external ear canal.
- The tympanic scale is easily recognised as a circular scale posterior to the eye.
- The auditory canal connects the middle ear with the pharynx.
- The columella, a thin shaft of bone, transfers vibrations from the tympanum to the inner ear.
- The middle ear is divided into lateral and medial sections by an extension of the quadrate bone.
- Chelonians have poor hearing. They only hear low-frequency sounds. Their hearing range is between 50 and 1500 Hz (the low-frequency sounds), compared to the normal human hearing range of 20–20 000 Hz. It is speculated that their ground-borne vibration sensitivity is good; however, this area has not been well studied.

1.5 Chelonian Behaviour

As with all captive species, it is essential that normal behaviours are recognised as normal, so that abnormal behaviours can be more readily identified. Many of these may be early warning signs for disease.

Even within those species of Chelonia kept commonly in captivity, there is considerable diversity. As such, this chapter will be a brief overview. For more detailed information, readers are referred to the reading list at the end.

Aggregation

Chelonian species are not social species. However, aggregation is observed in the field, though in studies of *Gopherus* species it is thought that this only occurs when population densities are high enough. In addition, urine and faeces from 'dominant' males was found to drive some animals away from group sleeping sites.

It is therefore possible to surmise that keeping groups of tortoises together may be stressful to some individuals, especially subordinate males.

Thermoregulation

All reptiles are poikilothermic – that is, they require external heat supplies and yet are able to regulate body temperature independent of environmental temperature to some degree. It is considered that reptiles tend to exist in a Preferred Optimal Temperature Zone (POTZ), within which they control their core temperature.

Chelonia obtain heat by basking – the carapace has a rich blood supply and a large surface area for this purpose. Therefore, overhead heat sources should be provided. Given that many species are adapted to avoiding excess cold/heat by digging, it seems inappropriate to provide contact heat sources. In addition, the plastron does not appear so well adapted to thermoregulation and prolonged heat mat contact can result in chronic low-grade burns.

Aquatic species (generally, the Soft-shelled species or the Mata mata) will bask in water and will require a shallower water depth under the heat lamp. Semi-aquatic species prefer a shelf or log on to which they can climb to bask.

There appears to be some ability to sense and predict temperature zones. All Chelonia (barring Soft-shelled turtles) have temperature-dependent sex determination, with the sex of the offspring largely being set by environmental temperatures (see Chapter 1.3). There appears to be evidence (certainly within sea turtles) of females selecting nest sites that will result in certain sex ratio skews, depending on the current population pressure. Selection of hibernation sites may also indicate similar abilities.

Many herpetologists believe that sick chelonians (especially those with lower respiratory disease) may, conversely, choose to inhabit the lower end of the POTZ. This would appear to be an attempt to lower the metabolic rate to match the oxygen supply when gas exchange is compromised. Persistent heat avoidance may therefore be an indication of illness. However, this is a short-term survival mechanism that, in the medium to longer term, will compromise the immune response. It is therefore NOT recommended to lower the environmental temperature as part of the therapeutic plan.

Hibernation is a feature of species from temperate zones. The basic stimulus for hibernation appears to be falling temperature. However, there does appear to be some evidence that this response is modified by light cycles. Studies in *Testudo hermanni* appear to show that both exposure to temperatures under 10 °C and light cycles of 16 hours dark/8 hours light were required to reduce both serotonin and melatonin to the low non-cyclical levels seen in hibernation.

Feeding

Feeding behaviours will vary according to diet.

The herbivorous species tend to forage over large distances, as many are adapted to live in arid/semi-arid areas and fibrous plant material. Care must be taken in captivity not to provide too rich a diet (i.e. succulent foods rich in simple carbohydrates) or obesity/growth deformities may result (see the nutrition section) as fewer calories are expended in seeking food.

When prehending food, many species will smell the food first, appearing to stand over the food and 'huff' (a deep panting breath with movement of the forelimbs – there may be an audible hiss with these breaths). They may then take a light, incomplete bite to 'taste' before beginning to feed properly. In the clinical setting, it is important to recognise these pre-feeding behaviours, especially in the typical anorexic hospitalised tortoise. These behaviours may indicate an animal that is ready to eat, but is not prepared to in the 'hostile' hospital setting. Most will commence eating at home provided that husbandry is adequate.

Diet may vary according to season with some more omnivorous species (e.g. red- and yellow-foot tortoises varying protein consumption between seasons).

Carnivorous species fall into two categories – those that actively forage for food and those that lie in wait for food. In chelonians, the majority fall into the latter category. In the former case (e.g. the Fly river turtle), feeding can be tailored to their activity level, with feeding reduced as the reptile loses interest, in order to avoid obesity and shell deformity.

In the latter case, it is much more difficult to regulate calorie intake to need, as many of these animals appear to be 'programmed' to take food whenever it is presented. Therefore feeding amounts and frequencies must be regulated in conjunction with regular assessment of body condition.

Drinking

Chelonia do not tend to drink as is understood in mammals – they do not lap or take from bowls/drinkers. All species take water by submersion of all or part of the head and pumping of the throat.

Terrestrial species tend to rely on water from food sources, though this can be unreliable in captivity. Therefore these species should be provided with the opportunity to bath and drink at least once a week.

It is commonly suggested that chelonians also ingest water via the cloaca. While this does occasionally appear to be the case in terrestrial species, it has only been scientifically recorded in aquatic species.

Social factors

Chelonia are not social species, though they may be gregarious at certain times. Mixing of incompatible species, or of individuals that are very different in size, may result in social 'bullying'.

This may particularly be the case in juveniles, where a larger animal drives the other off food – this can result in an ever-increasing size difference, with the smaller animal failing to thrive and in the larger one selectively feeding and developing shell deformities.

In such situations, the animals may need to be housed separately, either permanently or only at feeding times. A repressed juvenile may continue not to feed adequately if it can scent the presence of the other.

In aquatic carnivorous species, physical damage to the smaller individual may occur. Ideally, all carnivorous species should be fed separately, to avoid the 'feeding frenzy' situation where accidental damage can also occur.

The circadian cycle

Captive chelonians appear, where possible, to follow daily cycles based on body temperature requirements.

In general, for terrestrial herbivorous species, this will take the following form:

- Bask.
- Feed.
- Bask again – presumably to induce temperatures adequate for fermentation of food in the gut.
- During the remainder of the day, these animals seem able to maintain body temperature by varying behaviours between basking, sheltering from heat and feeding.
- As the temperature drops in the evening, animals will shelter in housing or bury in loose soil.

For carnivorous species, there is some variation. Certainly, they will commence the day basking. However, as they lack the need for fermentation of food, there is no requirement for post-feeding basking.

Reproductive

Male

There is little published work on male reproductive cycles. It is thought that chelonian species fall intermediate between androgen-associated and androgen-dissociated cycles of reproductive activity; however, there are no published studies that confirm this hypothesis.

Certainly in captivity, reproductive behaviours can be observed in male tortoises at all times of year if environmental conditions are suitable for metabolic activity.

In terrestrial species, male reproductive behaviours tend to be two phase. The first is visual and involves head bobbing. Eversion of chin glands during head bobbing in *Gopherus* species leads to speculation that the purpose of head bobbing is to release and direct pheromone chemicals.

The second phase is physical. Two males will proceed to ram each other – this may progress as far as overturning the rival.

Where the second animal is female and does not respond by head bobbing, the male will smell the cloacal region and, if identifying female pheromone of the correct species (it is felt that cloacal pheromones are very important in species recognition), will attempt to mate.

In *Testudo* species, there may also be considerable physical stimulation of the female, either ramming (Spur-thighed group) or biting (Hermann's, Marginated and Horsfield's tortoises). It is considered by some that these behaviours may represent a need for ovulation to be induced in the female. In captivity, this has led to considerable shell damage in females of the 'biting' species by male 'rammers' and extensive skin damage to Spur-thighed tortoises by 'biting' males (see Figure 34.4). However, whether this is normal male–female behaviour in an inappropriate setting is not clear. Studies in *Geochelone carbonaria* and *G. denticulata* show that males of one species will rarely attempt mating with females of the other species once they have smelt the cloacal pheromones. It is therefore possible that the aggressive behaviour in captive *Testudos* of different species may represent non-recognition of sex/species and thus attempted male-to-male aggression.

In aquatic species, there may be more elaborate courtship routines. This often involves chasing and scenting of the cloacal region. In some species (e.g. *Trachemys* spp.), the males have long curved claws on the forelegs and these are used to fan the female, presumably to direct pheromone towards her.

Female

As in males, studies of hormonal regulation in female tortoises are comparatively rare. In *Trachemys scripta elegans*, female reproductive cycles appear linked to oestradiol concentrations.

Female cycles appear to be linked to geographical area, with the dominant factor being temperature variation:

- Winter – metabolic inactivity.
- Spring – rising temperatures linked to follicular growth and vitellogenesis. This parallels spermiogenesis during the same period in males. The female is ready for ovulation in late spring.
- Summer – nesting period. Little follicular growth/activity. In some captive *Testudo* species, females have been observed to become more aggressive in this period.
- Autumn – early follicular growth prior to winter hibernation period.

In tropical species, there appears to be less cyclical activity and breeding timing is less predictable, being based more on food availability, rainfall and so on. Thus mating and egg laying can, potentially, occur throughout the year.

Even in cyclical species, there is potential for autumn mating/egg laying depending on environmental weather conditions. Similarly, there is some confusion between this and the capability of female tortoises to retain eggs for months/years before laying.

Most species held commonly in captivity are nest layers and so require access to adequate areas for this – namely, moderately deep areas of loose substrate. Given the observed ability of females to select nest sites dependent on need and their ability to retain eggs, it is best to provide several such sites in different temperature zones.

Defensive

Defensive behaviours may take the form of either passive behaviours or active ones.

Active defensive behaviours

Vocalisation is rare. However, many species (especially terrestrial) may vigorously exhale and hiss when alarmed.

Biting is commonly exhibited by the carnivorous aquatic species. Given the powerful sharp beak, these can cause considerable damage to the handler or to other animals, especially in the larger species.

Terrestrial tortoises may also bite, though this is normally only when a finger is placed on or around the mouth.

Many species (especially aquatic) will scrabble with their legs on being picked up. Damage can occur from the sharp claws.

Terrestrial species may urinate on being handled. Many have large bladders and it is felt that this acts as a water store. However, the manner in which large volumes are forcefully ejected suggests that this water store may also be used as a predator defence.

Given the dual nature of the bladder water store, some authors suggest that a tortoise induced to urinate is given a long bath in order to replenish the water reserve.

Passive defensive behaviours

The main defensive behaviour is that of retraction into the shell, and all Chelonia are capable of this to greater or lesser extent. Hinging of the shell (in, e.g., box turtles and hinge-backs) can enable complete coverage of the head and limbs when retracted. Otherwise, the hard scales of the distal limbs act to protect the retracted limbs and head. The presence of large sharp spurs on the hind limbs in some species (e.g. Leopard tortoise, African Spurred) can act as an additional defence, and can cause considerable pain if the handler does not release the animal's leg as it is being withdrawn into the shell.

Some semi-aquatic turtle species may release musking agents when alarmed.

Pain

Reptile pain is poorly understood and poorly described. Basically, any alteration from normal behaviour that occurs after a potentially painful incident (accident, injury, surgery etc.) may be taken as an indication of the reptile feeling pain.

In particular, the following may be used as pain indicators in chelonians:

- anorexia
- resentment of palpation – especially if vigorous and marked on palpating a certain point
- altered posture – raising of body OR dragging
- lameness
- ataxia
- biting at, or rubbing of, a lesion
- withdrawal of one or more limbs or head/tail
- avoidance of other individuals or owner contact
- closed eyes
- reduced activity levels

- neck stretching with or without mouth gaping
- vocalisation – *in extremis*, a screaming sound may be emitted

Further reading

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